

## **COST AND PERFORMANCE REPORT**

### **EXECUTIVE SUMMARY**

This report presents cost and performance data for a soil vapor extraction (SVE) system at the Basket Creek Surface Impoundment site in Douglasville Georgia. The SVE system was used at Basket Creek to treat soil contaminated with halogenated volatile organic compounds (VOCs), including trichloroethene (TCE) and tetrachloroethene (PCE), and nonhalogenated VOCs including toluene, xylenes, methyl isobutyl ketone (MIBK), and methyl ethyl ketone (MEK).

Basket Creek was used in the 1960s for illegal disposal of liquid refinery and other hazardous wastes; however information on the quantity and specific types of waste disposed in the impoundment is not available. In 1991, soil at the site was identified as a RCRA hazardous waste exhibiting the Toxicity Characteristic (TC) for lead, MEK, and TCE. Soil samples collected in March 1990, May 1991, and January 1992 showed the following concentrations in a total waste analysis: TCE - below detection limit (BDL) to 8,600 mg/kg; PCE - BDL to 2,700 mg/kg; toluene - BDL to 220,000 mg/kg; xylenes - BDL to 7,300 mg/kg; MEK - BDL to 23,000 mg/kg; and MIBK - BDL to 66,000 mg/kg.

An action memorandum for Basket Creek was signed on April 11, 1991 and specified soil treatment targets for TCE, PCE, benzene, MEK, lead, mercury, and total halogenated organic compounds (HOCs). The cleanup levels ranged from 0.2 to 200 mg/L (measured using a TCLP) for all contaminants except total HOCs. The target for total HOCs was 1,000 mg/kg, based on the land disposal restrictions for California List wastes. In addition, EPA and the State of Georgia required that the thermal oxidizer maintain a minimum destruction efficiency of 95%.

The SVE system used at Basket Creek was an ex situ application, consisting of a 7,200 ft<sup>2</sup> containment building, a shaker (power) screen, 17 vapor extraction wells, vacuum pumps, a baghouse, an induced draft blower, and a thermal oxidizer. Excavation, screening, and vapor extraction all took place inside the containment building. EPA had originally considered using in situ SVE, but ruled it out because of the relatively low permeability of soil (excavation and power screening helped to increase the permeability of the soils in the ex situ process). The system was run from November 1992 to February 1993, and again from March to April 1993, for a total of 6 months of operation.

Analytical data indicated that the soil treatment targets were met for all contaminants after the six month treatment period. Total VOCs in the treated soil ranged from 0.142 to 1570.7 mg/kg, and approximately 72,000 lbs of total VOCs were recovered from the soil. Toluene was the largest quantity VOC recovered, accounting for approximately 80% of the total VOCs recovered, and MIBK was the second largest quantity, accounting for 11%. The thermal oxidizer achieved a destruction efficiency of at least 95% during system operation, and for three months of at least 98%.

Approximately \$2.2 million were expended in this application, including \$1.3 million for before-treatment activities, \$660,000 for activities directly attributed to treatment, and \$220,000 for after-treatment activities, including off-site disposal of treated soil. Approximately \$650,000 of the before-

## **EXECUTIVE SUMMARY (CONT.)**

treatment costs were for the building (enclosure), air handling system, and treatment of building vapors in the incinerator.

The \$660,000 in costs directly attributed to treatment activities corresponds to \$413 per cubic yard treated (1,600 cubic yards), \$275 per ton of soil treated (2,400 tons), and \$9.20 per pound of VOC removed (approximately 72,000 pounds VOC removed). These unit costs reflect treatment of a relatively small quantity of soil that contained a relatively high concentration of contaminants.

According to the OSC, excavation within an enclosure takes longer than outside due to the space constraints. Normally, the excavation at Basket Creek would have been completed in a few days, instead of the three months actually taken.

## **SITE INFORMATION**

### **Identifying Information:**

Basket Creek Surface Impoundment site  
Douglasville, Georgia  
**CERCLIS #** GAD980843833  
**Action Memorandum Date:** 4/11/91

### **Treatment Application:**

**Type of Action:** Removal  
**Treatability Study Associated with Application?** Yes  
(see discussion under Remedy Selection)  
**EPA SITE Program Test Associated with Application?** No  
**Period of Operation:** 11/92 - 4/93  
**Quantity of Material Treated During Application:** Approximately 1,600 cubic yards (2,400 tons) of soil [2]

### **Background**

**Historical Activity that Contributed to Contamination at the Site:** Waste Disposal

**Corresponding SIC Code:** 4953 W (Refuse Systems - waste processing facility, miscellaneous)

**Waste Management Practice that Contributed to Contamination:** surface impoundment/lagoon

**Site History:** The Basket Creek Surface Impoundment site (Basket Creek) is located in Douglasville, Georgia, as shown in Figure 1. The site was contaminated during the 1960s when it was used for the illegal disposal of hazardous wastes. At that time, an intermittent stream bed was dammed with soil to form a small impoundment. The impoundment area measured 35 feet north to south and 50 feet east to west, and ranged in depth from 6 to 12 feet. [1, 2]

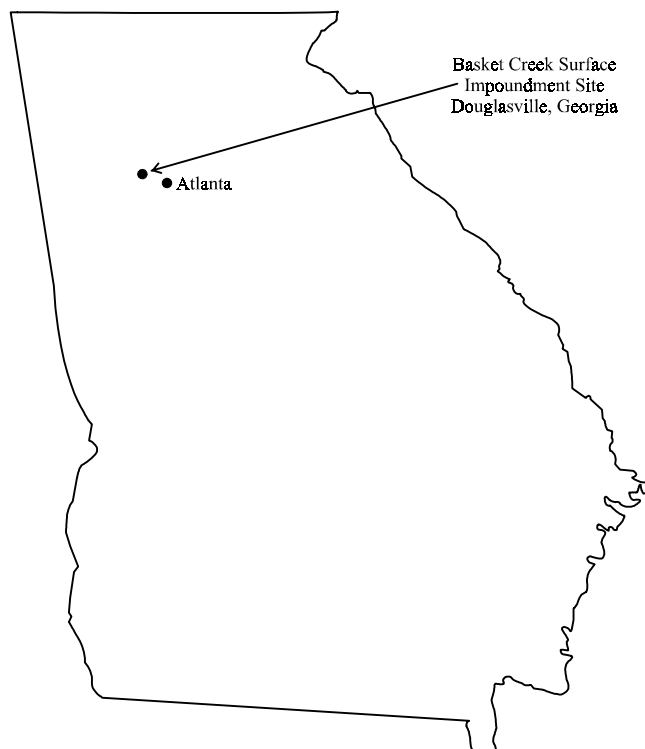
Liquid refinery and other hazardous wastes were reportedly disposed in the impoundment over a number of years. However, information on the quantity and specific types of waste disposed was not available. The impoundment was accidentally ignited in July of 1970 and burned for several days. Subsequent to the fire, local officials required the landowner to discontinue waste disposal and cover the impoundment with soil. [1,2]

In November 1989, EPA performed a Hazard Ranking System evaluation for Basket Creek. The evaluation was limited to a review of existing file material, completion of a target survey, and a site walk-through. Based on that evaluation, the site did not qualify for the National Priorities List (NPL). [3]

## SITE INFORMATION (CONT.)

### Background (cont.)

**Regulatory Context:** EPA signed an Action Memorandum for Basket Creek on April 11, 1991. Initial activities included sampling to characterize the nature and extent of contamination at the site. The soil was found to be a RCRA hazardous waste by exhibiting the Toxicity Characteristic (TC) for lead (Waste Code D008), methyl ethyl ketone (Waste Code D035), and trichloroethene (Waste Code D039). Additionally, the soil was found to be a California List Waste under the RCRA Land Disposal Restrictions program because total halogenated organic compounds were greater than 1,000 parts per million (ppm) and, therefore, waste from the site was prohibited from land disposal. As described under the Contamination Characterization section of this report, elevated levels of mercury were also found in the soil; however, the soil was not identified as exhibiting the TC for mercury. [3]



**Figure 1. Site Location**

The action memorandum identified treatment targets for soil, including TC regulatory levels for selected volatile organic compounds (VOCs) and metals, and the California List regulatory level of 1,000 ppm for total HOCs. [3]

**Remedy Selection:** EPA evaluated several potential remedies for this site. The first remedy evaluated, off-site incineration, was not selected because of cost. Bids for off-site incineration of soil from Basket Creek ranged from \$2,500 to \$2,800 per ton. [3] According to the OSC, the incineration bids were high because of the elevated mercury levels. [13]

Two on-site treatment technologies, in situ soil vapor extraction and low temperature thermal desorption, were also considered, and treatability studies were conducted for each technology. In situ soil vapor extraction was ruled out because of the low permeability of the contaminated soil.

During the low temperature thermal desorption treatability study, the soil sample ignited. This indicated that the soil was too highly contaminated with VOCs to treat safely with low temperature thermal desorption and EPA did not select this technology. [1]

## **SITE INFORMATION (CONT.)**

### **Background (cont.)**

The remedy selected by EPA for this site was ex situ soil vapor extraction (SVE). The remedy included excavating the soil from the impoundment, processing the soil through a power screen, stockpiling the soil on site, and treating the stockpiled soil with an ex situ SVE system. According to the OSC, the SVE system was installed primarily to control VOC emissions from the stockpile. [3, 13] According to the vendor, bench-scale testing was performed for this application; however, no details of the study or results were provided. [14]

Calculations were made to estimate the quantity of VOCs that would be released to the atmosphere from the excavation, screening, and stockpiling operations. The maximum quantity of VOCs released from the operations as fugitive emissions was estimated at 1,800 pounds per day. Depending on weather conditions, these emissions posed potential health risks for local residents and a threat to general air quality. EPA decided to include the following engineering controls to minimize fugitive emissions [3]:

- Construction of an enclosure large enough to cover the impoundment area and stockpile area;
- Development of an air handling system capable of exhausting a sufficient quantity of contaminated air to maintain a safe working environment in the building; and
- Installation of a thermal oxidizer (fume incinerator) to thermally destroy the VOCs in the air stream exhausted from the building.

### **Site Logistics/Contacts**

**Site Management:** Fund-Lead

**Oversight:** EPA

**On-Scene Coordinator:**

R. Donald Rigger  
U.S. EPA Region 4  
345 Courtland Street, N.E.  
Atlanta, Georgia 30365  
(404) 347-3931

**Treatment Vendor:**

Mark Rigatti  
OHM Remediation Services Corp.  
5335 Triangle Parkway, Suite 450  
Norcross, GA 30092  
(770) 453-7630

## MATRIX DESCRIPTION

### Matrix Identification

**Type of Matrix Processed Through the Treatment System:** soil (ex situ)

### Contaminant Characterization

**Primary Contaminant Groups:** Organic Compounds (Volatiles - Halogenated: trichloroethene; and Volatiles - Nonhalogenated: toluene, methyl isobutyl ketone, and methyl ethyl ketone) and Inorganic Compounds (Heavy Metals: lead and mercury)

Soil samples were collected by EPA in the surface impoundment in March 1990, May 1991, and January 1992, and analyzed for organics and metals. The results of these investigations for reported constituents are shown in Table 1.

The composite sample collected in May 1991 consisted of nine grab samples from various depths in the former impoundment. As shown in Table 1, the May 1991 sample was characterized by total waste analysis and Toxicity Characteristic Leaching Procedure (TCLP). The sample collected in January 1992 was collected as a "worst-case" sample (i.e., the most highly contaminated part of the site) for treatability testing. [2, 4, 9, 13]

**Table 1. Results of Soil Sampling for Reported Constituents in Surface Impoundment**

Constituent	Samples Collected March 1990 - Total Waste Analysis [9] (mg/kg)	Samples Collected May 1991 [4]		Sample Collected January 1992 - Total Waste Analysis* [2] (mg/kg)
		Composite Sample Total Waste Analysis (mg/kg)	Composite Sample TCLP (mg/L)	
Volatile Organics				
Trichloroethene	BDL (90)	BDL (90.0)	BDL (11.0)	8,600
Tetrachloroethene	BDL (120) - 720	230	BDL	2,700
Toluene	9,300 - 11,000	11,000	BDL	220,000
Ethylbenzene	BDL (220)	BDL (240)	BDL	1,600
Xylenes (total)	1,300 - 1,500	1,280	BDL	7,300
2-Butanone (Methyl Ethyl Ketone)	890	BDL	280.0	23,000
4-Methyl-2-Pentanone (Methyl Isobutyl Ketone)	1,400	4,700	BDL	66,000

**MATRIX DESCRIPTION (CONT.)****Contaminant Characterization (cont.)****Table 1. (Continued)**

Constituent	Samples Collected March 1990 - Total Waste Analysis [9] (mg/kg)	Samples Collected May 1991 [4]		Sample Collected January 1992 - Total Waste Analysis* [2] (mg/kg)
		Composite Sample Total Waste Analysis (mg/kg)	Composite Sample TCLP (mg/L)	
Metals				
Barium	58.15 - 103.14	63.0	BDL (0.326)	N/A
Cadmium	6.33 - 17.57	2.1	BDL (0.045)	N/A
Chromium	312.90 - 192.97	180.0	BDL (0.02)	N/A
Lead	667.88 - 2,579.67	4,400.0	32.6	940
Mercury	38.20 - 3553.68	190.0	0.1	390

\*This sample was collected as a "worst-case" sample for treatability purposes.

BDL - below detection limit (detection limit shown in parentheses, where available).

N/A - not analyzed.

**Matrix Characteristics Affecting Treatment Cost or Performance**

The major matrix characteristics affecting cost or performance for this technology and the values measured for each are shown in Table 2.

**Table 2. Matrix Characteristics [4]**

Parameter	Value	Measurement Method
Soil Classification	Not provided	Not provided
Clay Content and/or Particle Size Distribution	% Clay - 16.4 % Silt - 34.4 % Sand - 40.8 % Gravel - 8.4	Grain size analysis
Moisture Content	16.9%	N/A
Air Permeability	$1.5 \times 10^{-7}$ cm/sec	Not provided
Porosity	0.316	N/A
Total Organic Carbon	Not provided	N/A
Bulk Density	112.5 lbs/ft <sup>3</sup>	N/A
pH	5.46	N/A

N/A - Measurement method not reported for this parameter because resulting value not expected to vary among measurement procedures.

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## TREATMENT SYSTEM DESCRIPTION

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**Primary Treatment Technology Type:** Soil Vapor Extraction (ex situ)

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**Supplemental Treatment Technology Type:**

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Pretreatment: power screening,

Post-treatment (air): baghouse, thermal oxidizer

### **Soil Vapor Extraction System Description and Operation**

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#### System Design [1, 2, 11]

The SVE system used at Basket Creek included the following equipment: a metal building measuring 60 feet wide by 120 feet long by 26 feet tall; a shaker (power) screen; 17 horizontal vapor extraction wells; and three vacuum pumps for the vapor extraction system (with filters and silencers). In addition, the system included a baghouse (dust collector), an induced draft blower for exhausting the building air, and a thermal oxidizer to treat the contaminated air and vapor streams.

Figure 2 shows the layout for the treatment system used at Basket Creek. As shown in Figure 2, the vapors extracted from the soil stockpile were combined with the vapors extracted from the building air prior to treatment in the thermal oxidizer.

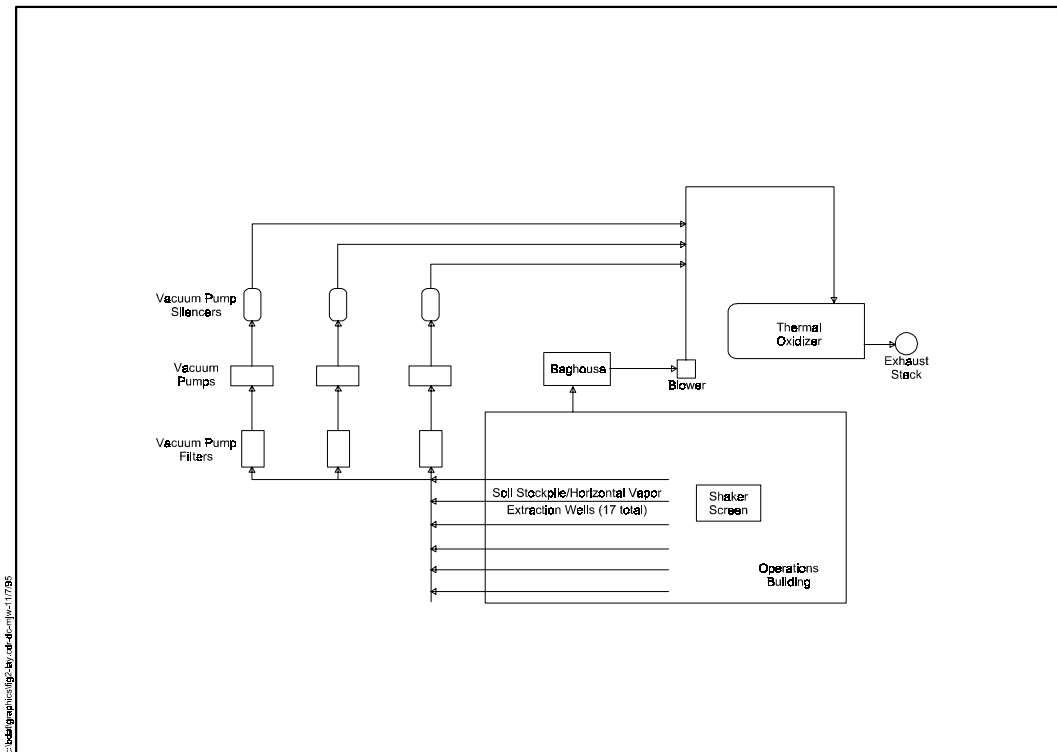
The building was designed to totally enclose the impoundment and also have sufficient room for treatment of the stockpiled soil. Inside the building, soil was excavated, processed through a power screen, and stockpiled. The soil was excavated using a track mounted excavator and placed directly into a power screen. The power screen was used to shred soil clumps and break up the soil to increase the soil permeability. The power screened soil was transported to the stockpile area using a 25-foot long covered stacking conveyor. According to the OSC, analytical data for vapors extracted from the building and soil stockpile showed that 20% to 25% of the VOCs recovered during this application came from the excavation and screening operations.

The soil vapor extraction system consisted of seventeen 4-inch diameter slotted well screen strings lying horizontally through the soil stockpile. The well screens were placed in three rows, six near ground level, five at 4 feet above ground level, and six more at 7 feet above ground level. Chemical resistant sleeves were placed over the well screen sections to prevent soil from clogging the slots. As the stockpile was built, additional well screen sections were screwed onto the previous section and covered with excavated soil. The vacuum for each well screen row was supplied by a 1,240-cubic feet per minute (cfm) vacuum pump. Each vacuum pump was equipped with a filter canister and a silencer to reduce the high pitched noise of the pump. Vapors were drawn out of the stockpile and routed to the thermal oxidizer through PVC piping.

In addition, vapors were collected using a movable fume hood at two locations inside the building: at the excavation; and at the power screen. The vacuum for the excavation and power screen was supplied by an 8,000-cfm, 50 horse power (hp) induced draft blower located outside the operations building. A baghouse was used to remove all particulates from the air stream. The baghouse consisted of a metal structure housing 96 filter bags designed to remove particles

## TREATMENT SYSTEM DESCRIPTION (CONT.)

### Soil Vapor Extraction System Description and Operation (cont.)



**Figure 2. Treatment System Layout [2]**

down to 0.5 microns. The system used 24-inch flexible duct work to route the vapors from the interior of the building to the exterior. Galvanized steel ducts were used to route the air through the baghouse and into the thermal oxidizer.

The thermal oxidizer was a three chamber, propane fired unit designed to treat 10,000 cfm of vapors with greater than 99% destruction and removal efficiency. Five 1,000-gallon propane tanks were staged on site to supply fuel for the unit.

#### System Operation [1, 2]

In October 1992, a trial burn of the thermal oxidizer was performed. Soil from the impoundment was exposed with a trackhoe and the soil was stirred to liberate VOCs. The contaminated vapor was routed through the duct work and into the thermal oxidizer which was operated at approximately 1,600°F. The residence time for the thermal oxidizer was not provided for this application. Mass emission rates were calculated for VOCs, semivolatile organic compounds, dioxins, and furans, and were reported to the Agency for Toxic Substances and Disease Registry (ATSDR - an agency of the U.S. Public Health Service). ATSDR determined that the predicted emissions from the thermal oxidizer would not pose a threat to public health. In addition,

## **TREATMENT SYSTEM DESCRIPTION (CONT.)**

### **Soil Vapor Extraction System Description and Operation (cont.)**

ATSDR recommended that stack emissions be continuously monitored. In response to this recommendation, continuous emission monitors (total hydrocarbon analyzers) were installed at the inlet and outlet of the thermal oxidizer.

Full-scale operations began in November 1992. The area of contamination (60 feet wide by 80 feet long and varying in depth to up to 14 feet) was divided into forty-eight 10-foot by 10-foot grids. Excavation was performed within individual grids to limit the surface area of exposed soil. Rocks and debris larger than 2 inches were rejected by the power screen, and placed in roll-off boxes. Excavation was halted when solid homogeneous rock was encountered.

The vapor extraction system was operated continuously; VOC recovery associated with the excavation and screening operations was operated an average of 25 to 30 hours per week, during excavation and screening operations. All of the recovered VOCs were routed to the thermal oxidizer for treatment.

#### **System Shutdown [2]**

In February 1993, excavation and backfilling of the 48 grid sections was completed. The vapor extraction system was operated for three weeks after excavation to complete treatment of the soil.

The stockpiled soil was then divided into 20-foot grid sections and sampled. The results indicated that the VOC levels in the majority of the grid sections had met the target levels (see discussion under cleanup goals/standards). However, the results also showed that contamination above the target levels still remained in several grid sections. These grids were re-excavated and treated in the stockpile SVE system in March and April 1993. Analytical results showed that in April 1993 the soil met the target levels (see results under Treatment Performance Data) and the soil was transported to the BFI industrial waste landfill in Buford, Georgia. A total of 2,366.72 tons of soil was transported off site for disposal.

Approximately 100 tons of rocks and debris from the power screening operation were disposed of at the BFI facility in Buford, Georgia. Eighteen (18) cubic yards of excavated metal and crushed drums were also transported off site in April 1993 to the Laidlaw Hazardous Waste Landfill in Pinewood, South Carolina, where they were disposed by direct burial. Approximately 4,250 gallons of decontamination water (from health and safety activities - see discussion below) were transported off site in May 1993 by International Petroleum Corporation for treatment at their facility in Fairburn, Georgia.

In addition, nine drums containing paint waste were transported in May 1993 to the Thermal-Chem facility in Rock Hill, South Carolina, for incineration.

## **TREATMENT SYSTEM DESCRIPTION (CONT.)**

### **Soil Vapor Extraction System Description and Operation (cont.)**

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#### **Site Restoration** [2]

Site restoration activities included dismantling and removal of the operations building and other process equipment. The site was then regraded using on-site soil, and grass seed and straw were distributed throughout the areas affected by the removal. In August 1993, the application of seed was completed.

#### **Health and Safety** [1, 2]

One of the main concerns regarding the safety of the personnel inside the operations building was the buildup of VOCs from the soil excavation and screening and the possibility of a fire or an explosion. To address these concerns, a site safety officer was present inside the enclosure at all times when excavation was taking place. Workers wore Level B personal protective equipment (PPE) consisting of supplied air breathing apparatus, fire resistant coveralls, disposable outer suits and boots, and hard hats. Workers decontaminated reusable PPE on site.

The safety officer was responsible for monitoring air quality inside the enclosure. A Combustible Gas Indicator was used to monitor the concentration of combustible gas in the airspace. A limit of 10% of the Lower Explosive Limit (LEL) was set as an automatic cease-work condition. If 10% of the LEL was reached, all work stopped and the workers evacuated the building until the levels had dropped back into the safe range. A Photo-Ionization Detector (PID) was also used to monitor airborne contaminants as total hydrocarbons. A limit of 500 ppm total hydrocarbons in air was also set as a cease-work condition.

Another safety concern was the potential to develop an explosive atmosphere in the air handling duct work, both inside and outside the enclosure. A limit of 20% of the LEL was set for all components of the air handling system, including the vapor extraction piping, the flexible duct work, and the steel duct work. Eight LEL detectors were placed throughout the air handling system, and connected to a central control panel. Whenever any one of the eight detectors registered 15% of the LEL, an audible alarm would sound, and personnel inside the building would discontinue excavation. A reading of 20% of the LEL caused automatic interlocks to activate which shut down the blower.

According to the OSC, the 15% LEL level in the duct work was exceeded several times per day during excavation of highly contaminated areas. In addition, there were several times during the project when the 20% level was exceeded. [13]

In addition, air monitoring was conducted around the perimeter of the operations building and using off-site high volume air sampling equipment.

## TREATMENT SYSTEM DESCRIPTION (CONT.)

### Operating Parameters Affecting Treatment Cost or Performance

The major operating parameters affecting cost or performance for this technology and the values measured for each are shown in Table 3.

**Table 3. Operating Parameters [13]**

Parameter	Value	Measurement Method
Air Flow Rate	3,000 cfm	N/A
Operating Pressure/Vacuum	4 inches mercury	N/A

N/A - Measurement method not reported for this parameter because resulting value not expected to vary among measurement methods.

### Timeline

A timeline for this application is shown in Table 4.

**Table 4. Timeline [1, 2]**

Start Date	End Date	Activity
April 1991	-	Action memorandum signed
April 1992	May 1992	Operations building constructed
October 1992	-	Trial Burn performed
November 1992	April 1993	Full-scale operations conducted
March 1993	May 1993	Treated soil disposed off site
May 1993	August 1993	Site restoration activities completed

## TREATMENT SYSTEM PERFORMANCE

### Cleanup Goals/Standards

The action memorandum identified treatment targets for stockpiled soil, including TC regulatory levels for selected volatile organic compounds (VOCs) and metals, and the California List regulatory level of 1,000 ppm for total HOCs, as shown in Table 5. [3]

**Table 5. Stockpile Soil Treatment Targets [3]**

Constituent/Parameter	Regulatory Level	Units
Trichloroethene (TCE) - TCLP	0.5	mg/L
Tetrachloroethene (PCE) - TCLP	0.7	mg/L
Benzene - TCLP	0.5	mg/L
2-Butanone (MEK) - TCLP	200	mg/L
Lead - TCLP	5.0	mg/L
Mercury - TCLP	0.2	mg/L
Total HOCs	1,000	mg/kg

According to the vendor, EPA and the State of Georgia identified a requirement that the thermal oxidation unit be at least 95% efficient for VOC destruction, although this is not described in the action memorandum. [14]

### Treatment Performance Data

Treatment performance data for this application include results for treated soil stockpile samples, power screen reject samples, total VOC and specific VOC recovery data, thermal oxidizer VOC destruction efficiency data, and air emission results.

#### Treated Soil Stockpile Samples [2]

The treated soil stockpile was sampled using a 20-foot grid system (a layout of the grid system was not provided). The stockpile was divided into fourteen 20-foot by 20-foot grid sections, and four sample points were selected from each grid section. The 14 grid sections are labelled:

AB-6,5;      AB-12,11;      CD-8,7;      DE-3,4;      EF-10,9; and  
 AB-8,7;      BC-3,4;      CD-10,9;      EF-6,5;      EF-12,11.  
 AB-10,9;      CD-6,5;      CD-12,11;      EF-8,7;

A hand auger was used to collect aliquots from 2-, 4-, and 8-foot depths at each of the four sample points within each grid section. All 12 aliquots were composited into one sample. The stockpile samples were analyzed by TCLP for TCE, PCE, benzene, MEK, lead, and mercury; and for total VOCs and total HOCs. The results from these analyses for the 14 grid sections are shown in Table 6.

**Table 6. Treated Soil Stockpile Analytical Data [2]**

Constituent/Parameter	Regulatory Level	Units	Sample Number						
			CD-10,9	EF-10,9	EF-12,11	CD-12,11	EF-6,5	CD-6,5	DE-3,4
Trichloroethene (TCE) - TCLP	0.5	mg/L	0.08	0.0015	BDL	BDL	0.0019	0.006	BDL
Tetrachloroethene (PCE) - TCLP	0.7	mg/L	0.12	0.038	0.019	0.0015	0.044	0.06	0.092
Benzene - TCLP	0.5	mg/L	0.001	0.0007	0.0003	0.0004	0.002	0.0017	0.017
2-Butanone (MEK) - TCLP	200	mg/L	0.7	0.066	BDL	BDL	0.52	0.83	1.5
Lead - TCLP	5.0	mg/L	0.75	0.71	1.1	0.6	0.28	0.27	0.62
Mercury - TCLP	0.2	mg/L	BDL	BDL	BDL	BDL	BDL	BDL	BDL
Total VOCs	N/A	mg/kg	249.91	38.47	0.347	0.382	70.04	166.59	230.8
Total HOCs	1,000	mg/kg	12.81	1.08	0.057	0.237	2.98	4.07	20.3

N/A - Not applicable - no cleanup goal established for this parameter.

BDL - Below detection limit (detection limit not provided).

MDL - Acronym not defined in references.

**Table 6. Treated Soil Stockpile Analytical Data [2] (Continued)**

Constituent/Parameter	Regulatory Level	Units	Sample Number						
			BC-3,4	AB-12,11	AB-10,9	AB-6,5	AB-8,7	CD-8,7	EF-8,7
Trichloroethene (TCE) - TCLP	0.5	mg/L	0.0024	BDL	BDL	0.0014	0.014	0.045	0.0007
Tetrachloroethene (PCE) - TCLP	0.7	mg/L	0.011	0.0013	0.17	0.011	0.13	0.26	0.046
Benzene - TCLP	0.5	mg/L	0.0022	0.0013	0.017	0.0015	0.019	0.025	0.0016
2-Butanone (MEK) - TCLP	200	mg/L	1.3	BDL	MDL	0.42	MDL	MDL	0.48
Lead - TCLP	5.0	mg/L	0.79	0.25	1.8	0.49	1.9	1.1	0.93
Mercury - TCLP	0.2	mg/L	BDL	BDL	BDL	BDL	BDL	BDL	BDL
Total VOCs	N/A	mg/kg	131.489	0.142	1,570.7	73.77	738.5	721.42	108.671
Total HOCs	1,000	mg/kg	2.709	0.055	7.3	0.66	10.97	18	5.521

BDL - Below detection limit.

MDL - Acronym not defined in references.

## TREATMENT SYSTEM PERFORMANCE (CONT.)

### Treatment Performance Data (cont.)

#### Power Screen Reject Samples [2]

The roll-off boxes containing rocks and debris from the power screening operation were also sampled. Power screen reject sample data were not provided. However, the vendor indicated that the material met the target levels, and was disposed at the Industrial Waste Landfill in Buford, Georgia.

#### Total VOC Recovery Data [2]

The quantity of total VOCs recovered from the surface impoundment was calculated by the treatment vendor using analytical data for the concentrations of VOCs at the inlet to the thermal oxidizer and the flowrate to the oxidizer. The vendor summed the calculated mass recoveries for the following VOCs to calculate total VOCs: TCE, PCE, benzene, toluene, ethylbenzene, total xylenes, MEK, MIBK, and chlorobenzene. The quantities of total VOCs recovered on a weekly basis from November 1992 to February 1993 are shown in Table 7.

#### Specific VOC Recovery Data

Table 8 shows a breakdown by VOC and by month for the total VOCs recovered from November 1992 to February 1993.

**Table 7. Quantity of Total VOCs\* Recovered [2]**

Operating Period	Quantity of Total VOCs* Recovered (lbs)
11/25 - 11/30/92	1,542.6
12/1 - 12/7/92	4,130.9
12/8 - 12/14/92	5,210.8
12/15 - 12/22/92	6,065.8
12/28 - 12/31/92	5,805.4
1/1 - 1/08/93	5,192.9
1/9 - 1/15/93	12,322.3
1/16 - 1/22/93	8,965.8
1/23 - 1/31/93	11,497.7
2/1 - 2/8/93	4,859.3
2/9 - 2/17/93	5,113
2/18 - 2/25/93	1,377.3
<b>TOTAL</b>	<b>72,083.8</b>

\*Total VOCs recovered are defined as the sum of the mass recoveries for the following: TCE, PCE, benzene, toluene, ethylbenzene, total xylenes, MEK, MIBK, and chlorobenzene.

**TREATMENT SYSTEM PERFORMANCE (CONT.)****Treatment Performance Data (cont.)****Table 8. Quantity of Specific VOCs Recovered [2, 5]**

VOC	Quantity Recovered (lbs)				Total*
	November 1992	December 1992	January 1993	February 1993	
TCE	0	182.4	265.05	177.88	625.33
PCE	0	0	179.64	171.01	350.65
Benzene	0	0	26.72	0	26.72
Toluene	1,543	18,813.0	29,851.67	6,889.01	57,096.28
Ethylbenzene	0	42.1	315.32	132.93	490.35
Total Xylenes	0	402.4	1,126.75	571.89	2,101.04
MEK	0	783.3	1,670.70	638.31	3,092.31
MIBK	0	989.8	4,523.07	2,761.27	8,274.14
Chlorobenzene	0	0	19.99	10.53	30.52
TOTAL*	1,543	21,213	37,979	11,349	72,083.8

\*Totals reflect rounding.

**Thermal Oxidizer Destruction Efficiency Data**

The destruction efficiency for the thermal oxidizer was measured based on the average daily inlet and outlet concentrations at the oxidizer. Table 9 shows these results for the months of November 1992, December 1992, January 1993, and February 1993.

**Table 9. Thermal Oxidizer Destruction Efficiency [2, 5]**

Operating Period	Average Daily Inlet Concentrations (ppmv)	Average Daily Outlet Concentrations (ppmv)	Destruction Efficiency (%)
11/25 to 11/30/92	10,944	573.60	95
12/1 to 12/31/92	181,032	3,828	98
1/1 to 1/31/93	432,960	3,878.4	99
2/1 to 2/25/93	149,328	1,125.6	99

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## TREATMENT SYSTEM PERFORMANCE (CONT.)

### Treatment Performance Data (cont.)

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The OSC speculated that the destruction efficiency performance improved during this application because the seals in the thermal oxidizer seated better after a 2-month break-in period. [13]

#### Air Emission Results

Airborne concentrations of VOCs inside the operations building occasionally approached 500 ppm (the stop work condition) and regularly ranged between 200 and 400 ppm. However, according to the OSC, no VOCs were detected during hourly air monitoring surveys around the perimeter of the operations building and no VOCs were detected in off-site high volume air samples. [1]

### Performance Data Assessment

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The soil stockpile analytical data shown in Table 6 indicates that the soil treatment targets were met for all 14 sampling grids after 6 months of treatment. As shown in Table 6, the TCLP results for the target compounds were as follows: TCE less than 0.1 mg/L, PCE less than 0.3 mg/L, benzene less than 0.03 mg/L, MEK less than 2.0 mg/L, and lead less than 2.0 mg/L. The TCLP results for mercury were all less than the reported detection limit. Also as shown in Table 6, total HOCs ranged from 0.055 to 20.3 mg/kg, and total VOCs from 0.142 to 1,570.7 mg/kg. The data in Table 6 also show that there were variations in concentrations among the 14 soil stockpile grid samples. For example, the total VOC data show a range over four orders of magnitude in the 14 grid samples (e.g., from 0.142 to 1,570.7 mg/kg).

Although no data are available to characterize the soil in the stockpile prior to treatment, the surface impoundment data shown in Table 1 present an approximation of the concentrations that may have been present in the stockpile prior to treatment. As shown in Table 1, total waste analysis concentrations in the surface impoundment ranged from Below Detection Limit (BDL) to 8,600 mg/kg for TCE, from BDL to 2,700 mg/kg for PCE, from 9,300 to 220,000 mg/kg for toluene, from BDL to 1,600 mg/kg for ethylbenzene, from 1,280 to 7,300 mg/kg for xylenes, from BDL to 23,000 mg/kg for MEK, and from 1,400 to 66,000 mg/kg for MIBK.

The data provided in Table 7 show that a total of 72,083.8 pounds of total VOCs were recovered from the soil stockpile in this application. This total includes VOCs recovered from the soil stockpile and the excavation and screening emissions. According to the OSC, 75 to 80% of the VOCs were recovered from the soil stockpile, with the remainder recovered from the excavation and screening processes. Table 7 also shows that the quantity of VOCs recovered varied over the course of the application. During the first six and latter three weeks of the application, total VOC recoveries averaged 4,400 lbs/week. However, during weeks 7, 8, and 9, total VOC recoveries averaged 11,000 lbs/week, approximately 2.5 times greater. According to the OSC, this was likely due to variations in VOC concentrations in the soils in the surface impoundment.

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## **TREATMENT SYSTEM PERFORMANCE (CONT.)**

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### **Performance Data Assessment (cont.)**

Table 8 shows that toluene was the largest quantity VOC recovered during this application, accounting for approximately 80% of the total VOCs recovered. MIBK accounted for approximately 11% of the recovered VOC, with the remainder consisting of TCE, PCE, benzene, ethylbenzene, xylenes, MEK, and chlorobenzene. These results are consistent with the data shown in Table 1 for soil sampling in the surface impoundment prior to this application. As shown in Table 1, for the composite sample collected in May 1991, toluene was present in the highest concentration (11,000 mg/kg), followed by MIBK at 4,700 mg/kg.

The thermal oxidizer destruction efficiency data show that, while the monthly average inlet concentrations varied from 10,944 to 432,960 ppmv, the oxidizer consistently met the requirement for a destruction efficiency of at least 95%. In addition, during December 1992, January 1993, and February 1993, when the monthly average inlet concentrations were greater than 100,000 ppmv, the destruction efficiency was at least 98%.

### **Performance Data Completeness**

Analytical data are available for the following: 1) the concentrations of contaminants in the surface impoundment prior to treatment; 2) the concentrations of contaminants in the soil stockpile after treatment was completed; 3) the quantity of total and specific VOCs recovered during 12 weeks of system operation; 4) the destruction efficiency for the thermal oxidizer; and 5) air emission results for inside the operations building, around the building perimeter, and at off-site locations.

No data are available to characterize the concentrations of contaminants in the soil stockpile just prior to system operation, or to compare with concentrations after treatment was completed.

### **Performance Data Quality**

Quality assurance/quality control (QA/QC) activities for this application included use of standard EPA protocols for sampling, including chain-of-custody procedures for sample transport, use of standard analytical methods such as SW-846 Methods 8260 and 1311 for TCLP analysis of volatiles, Methods 6010 and 1311 for TCLP analysis of metals (except mercury), Methods 7470 and 1311 for TCLP analysis of mercury, and use of matrix spike, matrix spike duplicate, and blank samples. Limited exceptions to protocol were noted by the analytical laboratory for some QA/QC activities. For example, for 3 of the 14 soil stockpile grid samples (AB-12,11, CD-12,11, and EF-12,11), the TCE and toluene matrix spike recoveries were not able to be determined by the analytical laboratory because of co-eluting interferences. [2] These exceptions are not believed to substantially impact the results for this application.

## TREATMENT SYSTEM COST

### Procurement Process

EPA was supported in the remediation at the Basket Creek Surface Impoundment site by OHM under a Response Engineering and Analytical Contract (REAC), and by Roy F. Weston under a Technical Assistance Team (TAT) contract and a REAC. OHM supported EPA in system design, construction, and operation, and used several subcontractors for these efforts. Under the TAT contract, Weston was tasked to perform soil sampling (prior to treatment) and air monitoring during treatment. Under the REAC contract, Weston was tasked to perform the thermal oxidizer trial burn. Both OHM and Weston summarized results from the application. [2,4]

Subcontracts for equipment purchases and leases were bid competitively in this application. [13]

### Treatment System Cost [1, 2, 12]

EPA reported total costs of approximately \$2.2 million dollars for OHM and Weston during this application, as shown in Table 10. Approximately 90% of the total costs were attributed to OHM's activities. Table 10 shows the specific activities reported by EPA for OHM's and Weston's costs. No additional information is available on the specific activities included under each item (e.g., OHM's "other cost" of \$1 million).

In order to standardize reporting of costs across projects, the total project cost was categorized according to the format for an interagency Work Breakdown Structure (WBS). The WBS specifies 9 before-treatment cost elements, 5 after-treatment cost elements, and 12 cost elements that provide a detailed breakdown of costs for activities directly associated with treatment.

Following the WBS, the OSC for the Basket Creek site categorized the total project cost into costs for before-treatment activities, shown in Table 11, costs directly attributed to treatment activities, shown in Table 12, and costs for after-treatment activities, shown in Table 13.

These costs were categorized using best professional judgement and experience with the application, as detailed invoices or other quantitative data were not available for this report. As such, the individual cost elements are estimated values based on an actual total project cost.

In categorizing the costs for this application according to the WBS, the OSC identified specific cost elements within the WBS and allocated a percentage of the total cost to each item. Tables 11, 12, and 13 show the cost elements identified by the OSC exactly as they appear in the WBS, and the specific activities identified by the OSC within each cost element. For example, under "site work" in Table 11, the OSC identified costs for excavation and soil preparation.

As shown in Table 11, approximately \$1,300,000 were expended in this application for before-treatment activities, such as monitoring, sampling, testing, and analysis, site work, and air pollution/gas collection and control. Table 12 shows \$660,000 expended for activities directly attributed to treatment, consisting of short-term operation (up to 3 years) and cost of ownership.

**TREATMENT SYSTEM COST (CONT.)****Treatment System Cost (cont.) [1, 2, 12]**

Table 13 shows \$220,000 expended for after-treatment activities including disposal of residuals, site restoration, and demobilization.

**Table 10. Total Costs Reported by EPA [2]**

Activity	Actual Cost (\$)
<b>OHM</b>	
Personnel	797,246.65
Equipment	67,809.90
Analytical	40,471.54
Transportation and Disposal	122,472.34
Other Cost	1,011,333.80
<b>TOTAL OHM COST</b>	<b>2,039,334.23*</b>
<b>Weston</b>	
Labor	98,736.06
Travel	136.38
Other Direct Costs	27,691.78
Project Administration	101,498.39
<b>TOTAL WESTON COST</b>	<b>228,062.61**</b>
<b>TOTAL PROJECT COST</b>	<b>2,267,396.80</b>

\*These costs are totalled from four delivery orders (4003-F4-005, 4001-F4-025, 4001-F4-027, and 4001-F4-038), and are current as of August 1993.

\*\*These costs are the actual direct and indirect cost incurred on this project from October 1990 through October 1994, and are current as of August 1993.

**Table 11. Before-Treatment Costs Shown Using WBS\* [1, 12]**

Cost Element	Estimated Cost (\$)
Monitoring, Sampling, Testing, and Analysis - Sampling, Analytical, Miscellaneous	260,000
Site Work - Excavation and Soil Preparation (Screening)	390,000
Air Pollution/Gas Collection and Control - Enclosure, Air Handling System, and Part of the Incinerator	650,000
<b>Total</b>	<b>1,300,000</b>

## TREATMENT SYSTEM COST (CONT.)

### Treatment System Cost (cont.) [1, 2, 12]

**Table 12. Treatment Costs Shown Using WBS\* [1, 12]**

Cost Element	Estimated Cost (\$)
Operation (Short-Term - Up to 3 Years) - Operating Costs, Personnel	130,000
Cost of Ownership - SVE System, Part of the Incinerator	530,000
Total	660,000

**Table 13. After Treatment Costs Shown Using WBS\* [1, 12]**

Cost Element	Estimated Cost (\$)
Disposal (Commercial)	130,000
Site Restoration	22,000
Demobilization	68,000
Total	220,000

\*The costs shown in Tables 11, 12, and 13 were categorized by the OSC according to the WBS using best professional judgement and experience with the application. The OSC indicated that part of the costs for the incinerator were incurred for treatment of vapors extracted by the excavation and power screening steps (before-treatment costs) and part for treatment of vapors from the soil stockpile (treatment costs).

The \$660,000 in costs directly attributed to treatment activities corresponds to \$413 per cubic yard of soil treated (1,600 cubic yards of soil in the surface impoundment), \$275 per ton of soil treated (2,400 tons), and \$9.20 per pound of VOC removed (approximately 72,000 pounds VOC removed). These unit costs reflect treatment of a relatively small quantity of soil that contained a relatively high concentration of contaminants.

### **Cost Data Quality**

The total costs described above represent actual costs for this treatment application as reported by EPA. Limited information is available on the specific activities included within the total cost figure.

The costs categorized according to the WBS shown in Tables 11, 12, and 13 are estimated values based on information provided by the OSC for this application. The estimates are based on best professional judgement and experience with the application.

## OBSERVATIONS AND LESSONS LEARNED

### Cost Observations and Lessons Learned

- Approximately \$2.2 million were expended in this application, including \$1.3 million for before-treatment activities, \$660,000 for activities directly attributed to treatment, and \$220,000 for after-treatment activities, including off-site disposal of treated soil. Because this ex situ application at Basket Creek was required to be performed in an enclosure, approximately \$650,000 in before-treatment costs were expended for the building (enclosure), air handling system, and treatment of building vapors in an incinerator.
- The \$660,000 in costs directly attributed to treatment activities corresponds to \$413 per cubic yard of soil treated (1,600 cubic yards), \$275 per ton of soil treated (2,400 tons), and \$9.20 per pound of VOC removed (approximately 72,000 pounds VOC removed). These unit costs reflect treatment of a relatively small quantity of soil that contained a relatively high concentration of contaminants.
- The \$2.2 million expended for the treatment application at Basket Creek was less than would have been expended for off-site incineration of soil. Based on bids ranging from \$2,500 to \$2,800 per ton, the projected cost for off-site incineration of 2,400 tons of soil would have been \$6 to 6.7 million.

### Performance Observations and Lessons Learned

- The soil stockpile analytical data indicates that the soil treatment targets were met for all 14 sampling grids after 6 months of treatment.
- In the 14 sampling grids, the TCLP results for TCE were consistently less than 0.1 mg/L, for PCE less than 0.3 mg/L, for benzene less than 0.03 mg/L, for MEK less than 2.0 mg/L, and for lead less than 2.0 mg/L. The TCLP results for mercury were all less than the reported detection limit. Total HOCs ranged from 0.055 to 20.3 mg/kg, and total VOCs from 0.142 to 1,570.7 mg/kg.
- The analytical data show that there were variations in concentrations among the 14 grid samples. For example, the total VOC data show a range over four orders of magnitude in the 14 grid samples, from 0.142 to 1,570.7 mg/kg.
- A total of 72,083.8 pounds of total VOCs were recovered in this application. This total includes VOCs recovered from the soil stockpile (75-80%) and the excavation and screening emissions (20-25%).
- The quantity of VOCs recovered varied over the course of the application. During the first six and latter three weeks of the application, total VOC recoveries averaged 4,400 lbs/week. However, during weeks 7, 8, and 9, total VOC recoveries averaged 11,000 lbs/week, approximately 2.5 times greater. According to the OSC, this was likely due to variations in VOC concentrations in the soils in the surface impoundment.

## **OBSERVATIONS AND LESSONS LEARNED (CONT.)**

### **Performance Observations and Lessons Learned (cont.)**

- Toluene was the largest quantity VOC recovered during this application, accounting for approximately 80% of the total VOCs recovered. MIBK accounted for approximately 11% of the recovered VOC, with the remainder consisting of TCE, PCE, benzene, ethylbenzene, xylenes, MEK, and chlorobenzene. Toluene and MIBK were also the contaminants measured in the highest concentrations in soil samples collected from the impoundment prior to the remediation.
- The analytical data show that the thermal oxidizer consistently achieved a destruction efficiency of at least 95% over 12 weeks of system operation. In addition, during December 1992, January 1993, and February 1993, when the monthly average inlet concentrations were greater than 100,000 ppmv, the destruction efficiency was at least 98%.
- Air emission results show elevated levels of VOCs inside the operations building; however, the concentration never exceeded 10% of the LEL or 500 ppm total hydrocarbons in the air, and work did not have to be stopped because of elevated levels in the building. In addition, no VOCs were detected during hourly air monitoring surveys around the perimeter of the operations building or in off-site high volume air samples.
- A comparison of data from soil samples in the impoundment prior to excavation and the soil stockpile after treatment show that the TCLP concentrations for TCE and MEK in the 14 sampling grids after treatment (TCE less than 0.1 mg/L; MEK less than 2.0 mg/L) were less than the TCLP concentrations in the pre-excavation samples. For example, in May 1991, TCE was measured as less than 11.0 mg/L, and MEK as 280 mg/L. However, it should be noted that there are no samples of untreated soil from the stockpile.
- While SVE was not expected to reduce the concentrations of lead and mercury in the soil, a comparison of data from soil samples in the surface impoundments prior to excavation and the soil stockpile after treatment show the TCLP concentrations for lead in the 14 sampling grids after treatment were less than the concentrations in the pre-excavation samples (for example, 32.6 mg/L before-treatment in May 1991, 0.25-1.9 mg/L after-treatment). However, as for the VOCs, there are no samples of untreated soil from the stockpile. As such, the OSC believed the reduction is due to the pre-excavation samples not being representative of the area of contamination as a whole, rather than as a result of treatment.

## **OBSERVATIONS AND LESSONS LEARNED (CONT.)**

### **Other Observations and Lessons Learned**

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- EPA selected ex situ SVE for this application. In situ SVE was ruled out because of the low permeability of the contaminated soil. Low temperature thermal desorption was eliminated because the soil was too highly contaminated, and, during a treatability study, a soil sample ignited. Incineration was ruled out because it was estimated to be approximately three times more expensive than the selected remedy.
- The OSC made the following observations about this application:
  - The excavation and power screening activities associated with the ex situ SVE application greatly increased the soil permeability. The power screening shredded soil clumps and broke up the soil. Soil permeability was not, however, measured after the power screening.
  - There were limitations associated with the materials of construction used for the soil stockpile. While building the soil stockpile, there was trouble maintaining the spacing of the horizontal wells because they were made out of PVC and would bend under the weight of the soil. The OSC indicated that carbon steel pipes would have been more rigid, but would have cost more.
  - It was important to oversize the air handling system for venting the building. The oversized system helped to prevent safety problems due to an explosive atmosphere in the building and in the ductwork. For example, during excavation of hot spots, VOC concentrations in the ductwork of the building vent system were greater than 1,000 ppm.
  - Excavation within an enclosure takes much longer than outside due to the space constraints. The OSC indicated that the excavation at Basket Creek would have been completed within a few days. However, excavation within the enclosure at Basket Creek took 3 months.

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### **Analysis Preparation**

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